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KEITHLEY

Operator's Manual

Model 191

Contains Operating Instructions for
Models 191 and 1910.

Keithley Instruments, Inc.

28775 Aurora Road/Cleveland, Ohio 44139/(216) 248-0400

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We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof which, within a year after shipment, proves defective upon examination. We will pay local domestic surface freight costs.

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MODEL 191
OPERATOR'S MANUAL

Contains Operating Instructions for
Models 191 and 1910.

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SECTION 1. GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. The Keithley Model 191 is a 5-1/2 digit, 200,000-count, manual-ranging bench digital multimeter with dc volts and ohms ranges standard. It provides highly accurate, stable, low noise and fast-responding readings from $1\mu\text{V}$ to 1200 volts dc on 5 voltage ranges, and 2 and 4 terminal measurements from 1 milliohm to 20 megohms on 6 resistance ranges. The 191 is capable of 0.0005% resolution and $1\mu\text{V}/1\text{m}\Omega$ sensitivity. In addition, if you purchased the Model 1910 AC Voltage Option, your DMM will provide readings from $10\mu\text{V}$ to 1000 volts ac on 4 ranges. This option may also be purchased later, and field installed.

1-3. Your DMM also has features and advantages that might not be readily apparent. Some of these are:

- 5-1/2 digit LED display with appropriate decimal point - 0.5 inch digits permit monitoring measurements from across the room.
- Pushbutton NULL - eliminates potentiometer zeroing, corrects for lead resistance in 2-wire ohms, bucks out thermal EMF's in low level dc measurements and permits you to measure deviations from a set value. The NULL light indicates that the function is active for operator safety and to lessen the chance of measurement error.

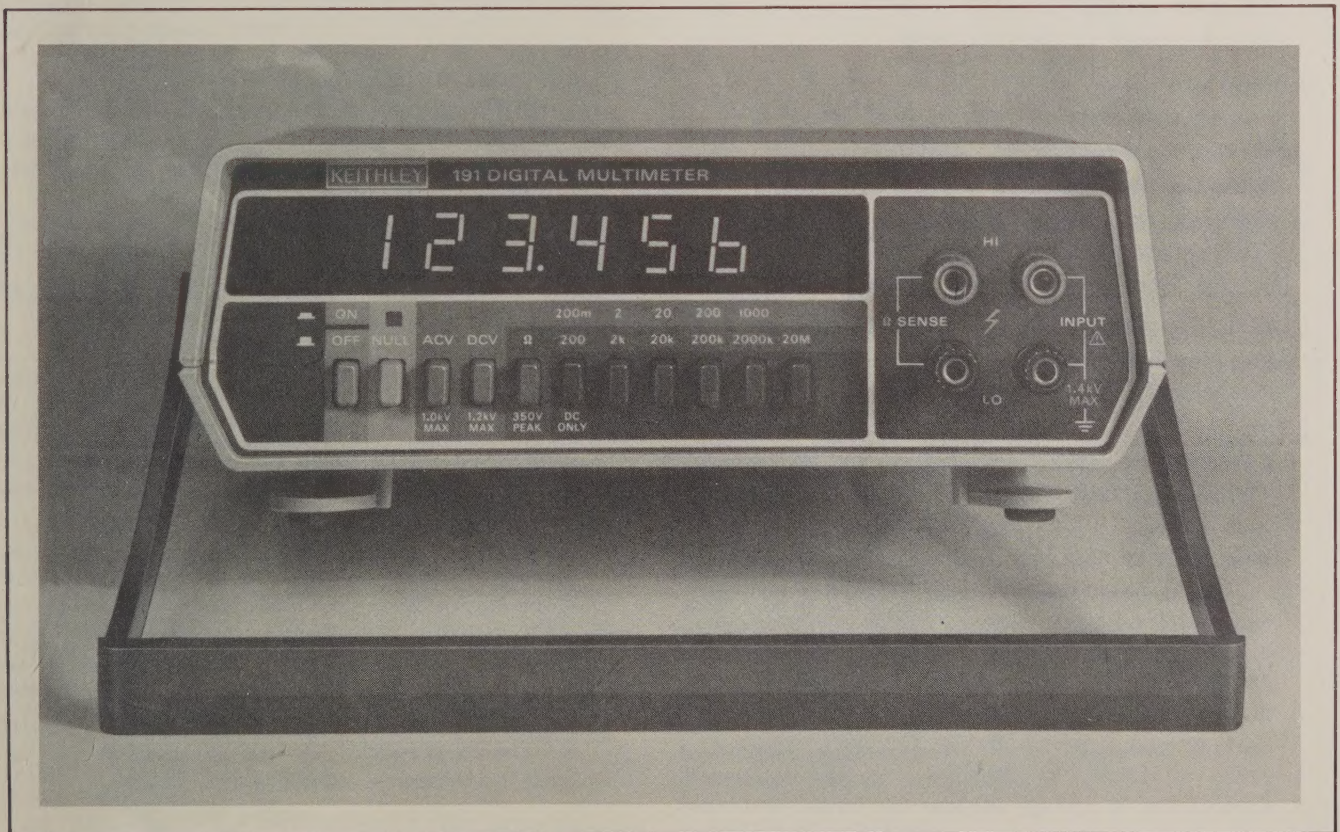


FIGURE 1-1. Model 191 Digital Multimeter

1-3. Continued.

- A Micro-processor based design that provides:
 - A Combination of single slope and charge balance AD conversion - for faster response and better linearity.
 - Automatic non-linear digital filtering - for faster response and reduced noise on the display.
 - A reduction in the number of parts while maintaining high accuracy and speed of measurement - simplifies high accuracy measurements and calibration of the instrument and provides higher mean time between failures.
- -IEEEE error message indicates improper uses of the instrument - prevents erroneous readings and reduces possibility of injury to the user or damage to the instrument.
- Each range has:
 - Automatic polarity operation - minus sign displayed, positive implied.
 - Effective input overload protection.
 - Overrange indication - polarity and overrange digit displayed.
 - Decimal point positioned by range pushbutton.
- Automatic 2/4 wire ohms operation - saves time and simplifies 2-wire or 4-wire ohms measurements.
- A full line of optional accessories that extend the measurement capability of your Model 191. Some of these are:
 - High voltage Probe allows your DMM to measure from 1200V to 40kV dc.
 - Plug-In Current Adapter allows your DMM to read dc current from 1nA/digit to 2000mA. With the AC Voltage option, it reads from 10nA/digit to 2000mA ac.
 - High Frequency (RF) Probe allows your DMM to measure from 0.25V to 30V rms ac over a frequency range of 100kHz to 100MHz. It can be used without the AC Voltage Option.
 - Clamp-On AC Current Probe (when used with AC Voltage Option) allows your DMM to measure from zero to 200A rms ac.

50-Ampere Current shunt allows your DMM to measure from 0-50A dc, and with AC Voltage Option from 10A to 50A rms ac.

NOTE

Refer to Section 2 for more detailed information on these accessories.

1-4. WARRANTY INFORMATION.

1-5. The Warranty is given on the inside front cover of this Instruction Manual. If there is a need to exercise the Warranty, contact the Keithley Representative in your area to determine the proper action to be taken. Keithley maintains service facilities in the United Kingdom and West Germany, as well as in the United States. Check the inside front cover of this Manual for addresses.

1-6. CHANGE NOTICES.

1-7. Improvements or changes to the instrument which occur after printing of the Instruction Manual will be explained on a Change Notice sheet attached to the inside back cover.

1-8. SAFETY SYMBOLS.

1-9. Safety symbols used in this manual are as follows:

IMPORTANT

The  symbol can be found in various places in this Manual. Carefully read the associated CAUTION statements with regard to proper use and handling of the instrument. Damage to the instrument may occur if these precautions are ignored.

This  symbol can be found in various places in this Manual. This symbol indicates those areas on the instrument which are potential shock hazards. Carefully read the associated WARNING statements with regard to proper use and handling of the instrument. Serious personal injury may result if these precautions are ignored.

1-10. SPECIFICATIONS

1-11. Detailed specifications for the Model 191 are given in Table 1-1.

TABLE 1-1
SPECIFICATIONS

DC VOLTAGE

RANGE	MAXIMUM READING	ACCURACY $\pm$ (% rdg + digits)		TEMPERATURE COEF. $\pm$ (% rdg + digits)/°C 0-18°C & 28-50°C	INPUT RESISTANCE	MAXIMUM ALLOWABLE INPUT	SETTLING TIME ³
		24 Hr 22-24°C	1 yr 18-28°C				
200mV	199.999	.005 + 2d ¹	.007 + 3d ¹	.0007 + 1.6d	> 1000Mohm	1200V ²	0.5 sec ⁴
2 V	1.99999	.004 + 1.5d	.007 + 2d	.0007 + 0.2d	> 1000Mohm	1200V ²	0.5 sec
20 V	19.9999	.004 + 1.5d	.010 + 2d	.0008 + 0.2d	10Mohm	1200V	0.5 sec
200 V	199.999	.004 + 1.5d	.010 + 2d	.0008 + 0.2d	10Mohm	1200V	0.5 sec
1200 V	1200.00	.005 + 1.5d	.010 + 2d	.0012 + 0.2d	10Mohm	1200V	0.5 sec

NMRR: > 60dB at 50 & 60 Hz.

CMRR: > 120dB at DC, 50 & 60 Hz (with 1kohm in either lead).

¹With zero set by Null function.²1 minute max., 700 volts continuous.³To within 5 digits of final reading.⁴1.6 sec. for input changes < 15 microvolts.

RESISTANCE

RANGE	MAXIMUM READING	ACCURACY $\pm$ (% rdg + digits)		TEMPERATURE COEF. $\pm$ (% rdg + digits)/°C 0-18°C & 28-50°C	MAXIMUM OUTPUTS		SETTLING TIME ³	4-TERMINAL LEAD RESISTANCE ⁴
		24 Hr 22-24°C	1 Yr 18-28°C		I short	V open		
200 ohm	199.999	.006 + 2d ¹	.012 + 3d ¹	.0015 + 2d	-4mA	-400mV	1 sec. ³	7ohm
2kohm	1.99999	.006 + 1.5d	.012 + 2d	.0015 + 0.2d	-4mA	-4 V	1 sec.	22ohm
20kohm	19.9999	.006 + 1.5d	.012 + 2d	.0015 + 0.2d	-400μA	-4 V	1 sec.	70ohm
200kohm	199.999	.006 + 1.5d	.012 + 2d	.0015 + 0.2d	-40 μA	-4 V	1 sec.	220ohm
2000kohm	1999.99	.01 + 1.5d	.03 + 2d	.002 + 0.2d	-4 μA	-4 V	1 sec.	700ohm
20Mohm	19.9999	.04 + 1.5d	.08 + 2d	.006 + 0.2d	-4 μA	-4 V	2 sec.	2200ohm

CONFIGURATION: 4 terminal or 2-terminal.

MAXIMUM ALLOWABLE INPUT: 360V peak, 250V rms.

¹With zero set by Null function.²To within 5 digits of final reading.³3 sec. for input changes < 15 milliohms.⁴Maximum resistance per lead for additional 1 digit error.

AC VOLTAGE (Option 1910)

RANGE	MAXIMUM READING	ACCURACY $\pm$ (% rdg + digits) (Above 1000 Counts) ¹ 1 Year 18-28°C		TEMPERATURE COEFFICIENT $\pm$ (% rdg + digits)/°C 0-18°C & 28-50°C	
		50Hz-20kHz	20-50Hz & 20k-100kHz	50Hz-20kHz	20-50Hz & 20k-100kHz
2V	1.99999	0.10 + 10d	1.0 + 20d	0.015 + 0.5d	0.05 + 0.5d
20V	19.9999	0.10 + 10d	1.0 + 20d	0.015 + 0.5d	0.05 + 0.5d
200V	199.999	0.10 + 10d	1.0 + 20d	0.015 + 0.5d	0.05 + 0.5d
1000V	1000.00	0.15 + 10d ²	1.0 + 20d ³	0.020 + 0.5d ²	0.05 + 0.5d ³

RESPONSE: Average, calibrated in rms of a sinewave.

MAXIMUM ALLOWABLE INPUT: 1000V rms sine or DC, 2 x 10⁵V • Hz.

SETTLING TIME: < 1.3 seconds to within 0.05% of final reading for zero to full-scale step input.

CMRR: > 60dB at DC, 50 & 60 Hz. (1kohm in either lead)

INPUT IMPEDANCE: 2Mohm shunted by less than 50pF.

¹With input shorted, display reads approximately 20 digits.²50Hz-10kHz.³20Hz-50Hz & 10kHz-20kHz.

GENERAL

NULL: Pushbutton allows zeroing of on scale readings. Front panel annunciator indicates null mode.

DISPLAY: Six 0.5 inch LED digits with appropriate decimal point.

CONVERSION SPEED: 4 readings/second on DC volts.

3 readings/second on ohms.

2 readings/second on AC volts.

POLARITY: Automatic, minus indicated, plus implied.

RANGING: Manual.

OVERLOAD INDICATION: Display indicates polarity and overrange digit only.

INVALID RANGE/FUNCTION SELECTION: Display reads -1EEEE.

ISOLATION: Input LO to power line ground, greater than 1000 megohms shunted by approximately 300 picofarads. Maximum input between LO and power line ground, 1400 volts peak, 5 x 10⁵V • Hz.

WARMUP: 1 hour to rated accuracy.

ENVIRONMENTAL LIMITS:

Operating: 0°C to 50°C, 0% to 80% relative humidity up to 35°C.

Storage: -25°C to 65°C.

POWER: 105-125 or 210-250 volts (internal switch selected), 50-60Hz, 25 V•A maximum.

INPUT CONNECTORS: 5-way binding posts.

DIMENSIONS, WEIGHT: 85mm high x 235mm wide x 275mm deep (3½ in. x 9¼ in. x 10¾ in.). Net weight: 2.3kg (5 lbs).

ACCESSORIES SUPPLIED: Model 1915 Instruction/Service Manual.

AVAILABLE ACCESSORIES:

Model 1010 Single Rack Mounting Kit

Model 1017 Dual Rack Mounting Kit...

Model 1600 High Voltage Probe

Model 1641 Kelvin Test Lead Set

Model 1651 50 Ampere Shunt

Model 1681 Clip-On Test Lead Set

Model 1682 RF Probe

Model 1683 Universal Test Lead Set

Model 1684 Carrying Case

Model 1685 Clamp-On Current Probe

Model 1901 Current Adapter

Model 1910 AC Volts Option

Model 1913 Calibration Cover

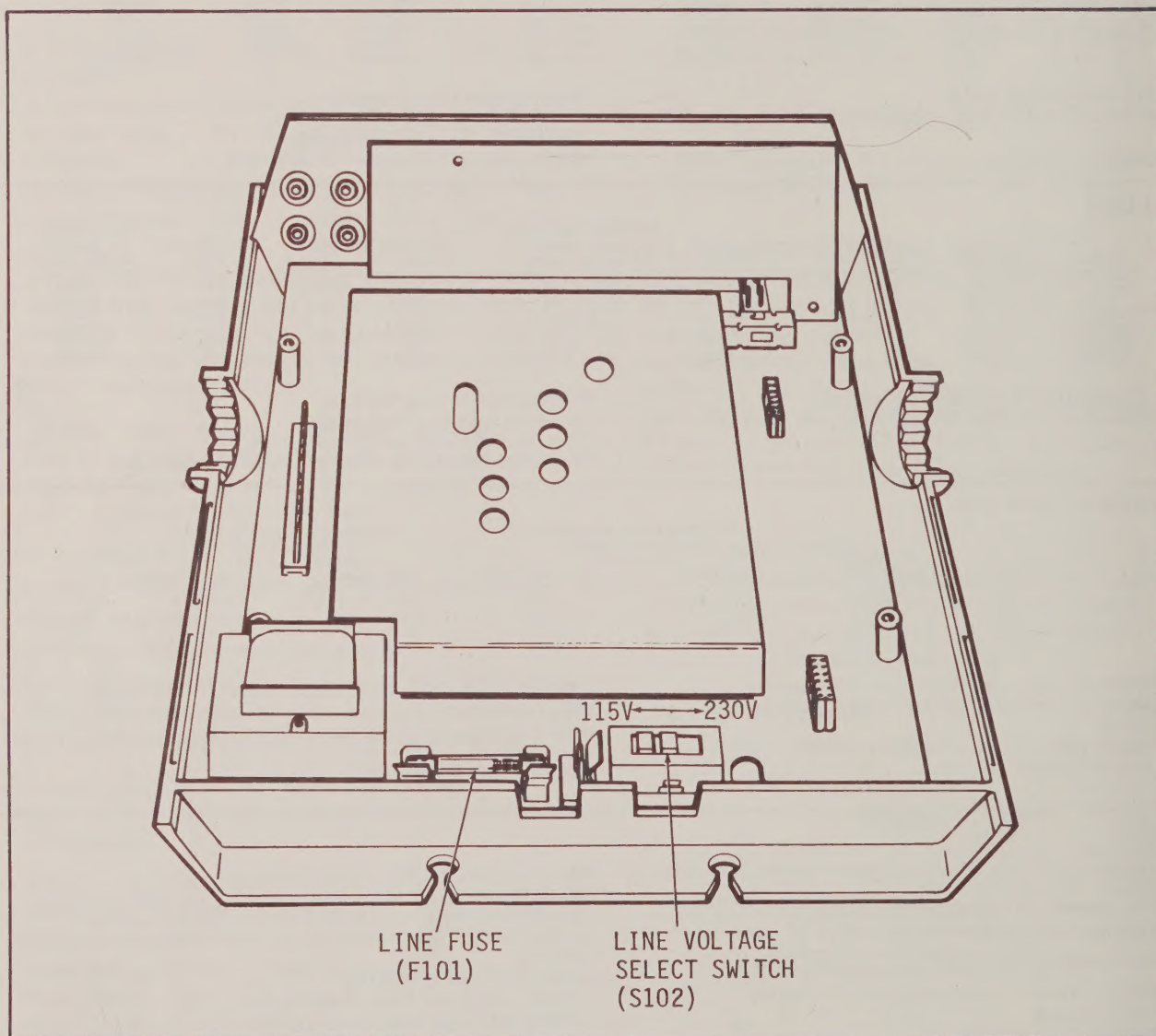


FIGURE 2-1. Location of Line Fuse and Line Voltage Select Switch.

SECTION 2. OPERATION.

2-1. INTRODUCTION.

2-2. This section provides information needed for incoming inspection, preparation for use and operation of the Model 191 and its accessories.

2-3. UNPACKING AND INSPECTION.

2-4. The Model 191 was carefully inspected, both mechanically and electrically before shipment. Upon receiving the Model 191, unpack all items from the shipping container and check for any obvious damage which may have occurred during transit. Report any damages to the shipping agent. Retain and use the original packaging materials if reshipment is required. The following items are shipped with all Model 191 orders:

- a. Model 191 DMM.
- b. A Copy of this Manual.
- c. Installed or separate optional accessories, as ordered.

2-5. PREPARATION FOR USE.

2-6. The Model 191 is shipped ready-for-use on the line voltage marked on its rear panel. Instructions on how to connect the Model 191 to your available ac line power are contained in Paragraph 2-7 Line Power.

2-7. LINE POWER

2-8. The Model 191 is provided with a 3-wire line cord which mates with a 3rd wire earth grounded receptacle. The instrument will operate on 3 voltage ranges of 60 or 50 Hertz ac power. Standard voltage ranges are 105 to 125 volts and 210 to 250 volts. Either of these ranges may be selected by positioning an internal slide switch and installing the appropriate fuse for that range. An optional line voltage range of 90 to 110 volts is available by special order. Instruments with this range use a different transformer. Connect the Model 191 to your available ac power in accordance with the following procedures:

NOTE

The line voltage that the instrument is set up for is marked on the rear panel. The following procedure can be used to either confirm the factory setting, or to set up the instrument for operation on another voltage range. If the line voltage range is changed, the box next to the selected line voltage should be appropriately marked as an external reminder of the setting. Use a water soluble marking pen.

2-9. Line Voltage Selection.

2-10. Set up the Model 191 to operate on your available ac line voltage as follows:

- a. Turn the DMM bottom side up and loosen the four screws in the bottom cover. These screws are held captive by rubber O-rings.
- b. Hold the top and bottom cover together to prevent their separation and turn the DMM over to normal position. Remove the top cover.
- c. Set switch S102 and install the proper rated line fuse, as indicated in Table 2-1, for your available input line voltage. These items are shown in Figure 2-1.
- d. Reinstall the top cover.

TABLE 2-1.
Line Voltage Selection.

INPUT VOLTAGE	SWITCH S102	FUSE F101
90-110V*	115V	1/4A
105-125V	115V	1/4A
210-250V	230V	1/8A

*Requires special factory installed transformer.

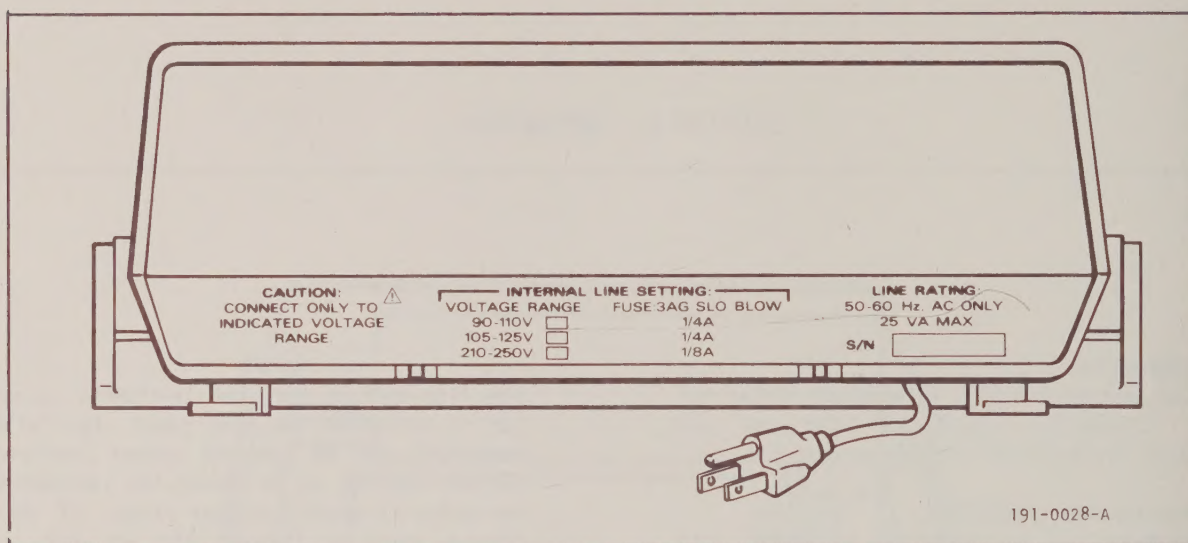


FIGURE 2-2. Rear View Showing Line Cord.

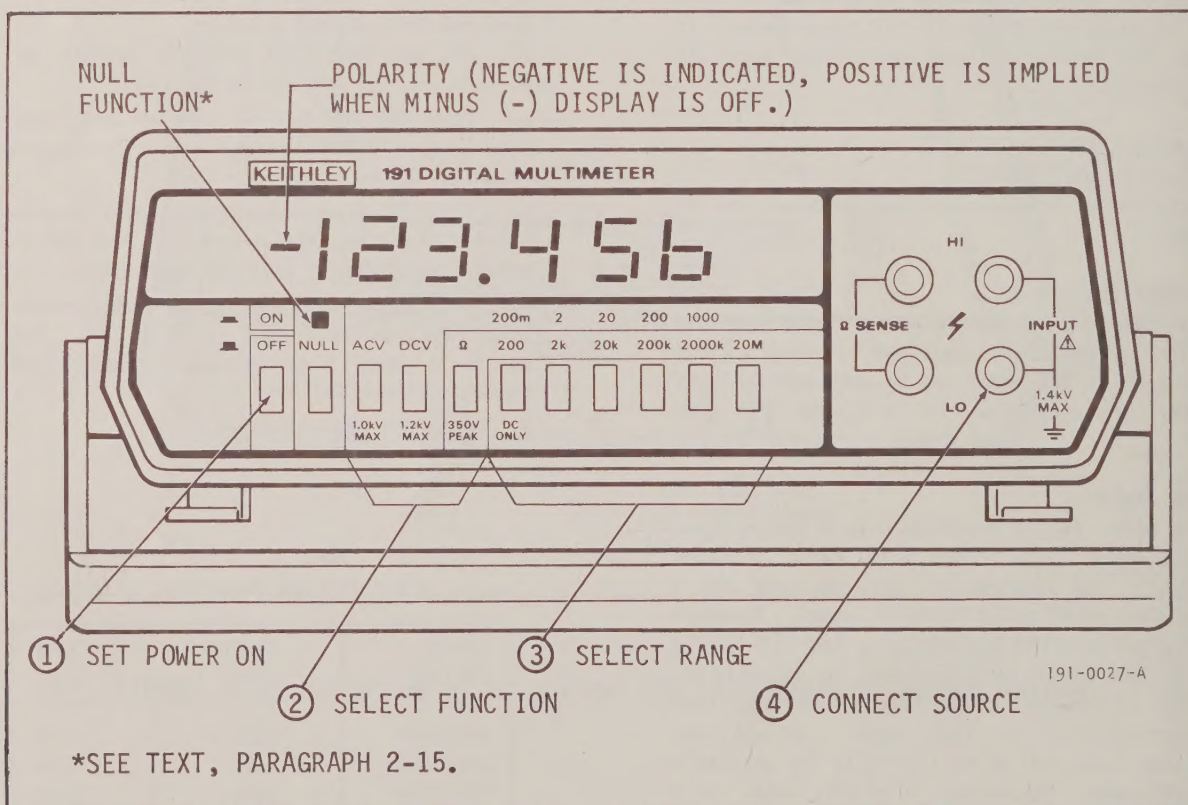


FIGURE 2-3. Operating Controls.

2-11. Connecting Line Power.

2-12. The Model 191 is provided with a 3-wire line cord, shown in Figure 2-2, which mates with third-wire grounded receptacles. Connect the instrument to ac line power as follows:

**WARNING**

Ground the instrument through a properly earth-grounded receptacle before operation. Failure to ground the instrument can result in severe injury or death in the event of short circuit or malfunction. In addition, connect only to the line voltage selected. Application of incorrect voltage can damage the instrument.

- a. Plug the power cord into a properly grounded outlet of a source having the selected line voltage.
- b. Operate the Model 191 as described in Paragraph 2-13.

2-13. OPERATING INSTRUCTIONS

2-14. The basic operating instructions for the Model 191 DMM are outlined below, and Condensed Operating instructions are provided on the bottom cover of the instrument. These instructions should only be used after becoming completely familiar with the operation of the Model 191 through day-to-day use. Until this familiarity has been achieved, best performance and safest operation will be obtained by using the individual instructions provided in this section which describe how to make specific function measurements. Refer to Figure 2-3 and operate the DMM as follows:

**CAUTION**

Do not exceed the Maximum Inputs limits given in Table 2-2.

- a. Turn on the power by depressing the ON/OFF pushbutton. If the instrument is within 18-28°C, it is useable immediately, but a 1 hour warmup is required to obtain rated accuracy. Up to 1 additional hour may be required from temperature extremes.
- b. Select the function with the ACV, DCV or Ω pushbuttons.
- c. Select the range by depressing the appropriate pushbutton.
- d. Connect the source to the INPUT terminals and make the measurement. Accessories described in Paragraph 2-29 should be used as required.

TABLE 2-2
Summary of Maximum Inputs.

FUNCTION	RANGE	MAXIMUM INPUT
DCV	200mV, 2V	700V Continuous; 1200V for 1 minute maximum.
	20V-1200V	1200V Continuous
Ω (ohms)	ALL	250V rms; 360V peak
ACV (Option)	ALL	1000V rms sine or dc; 2×10^7 V $\cdot$ Hz

2-15. NULL FUNCTION.

2-16. The NULL function is operable on all ranges and functions. It is a switch selectable software based function. The annunciator is lighted when the function is selected. When the NULL pushbutton is depressed with an on-scale reading on the display, that reading is subtracted from all subsequent readings. The nulling process is merely a subtraction of two numbers, and has nothing to do with the range or function selected. For this reason, although primarily designed to provide convenient pushbutton compensation for test lead resistance and thermal emf's generated in circuits connect to the DMM INPUT terminals, the null function can also be used to measure variations above or below a set value. For example, +1.00000 VDC input could be used to null the display, and variations above 10.0000M Ω could be made by switching to the 20M Ω range and Ω function. This is possible because the number being subtracted is 100,000 (counts) in both instances, and the minus sign is active for Ω (and ACV) in the NULL mode.

2-17. It is important to note that the use of NULL reduces the dynamic range of measurement. For instance, if +1.00000 VDC is the nulled value, input voltages greater than 2V would still overload the A/D converter (200,000 counts), even though over-range would occur at $\approx$ 100,000 counts displayed, and readings less than -1V would cause overrange (2V less than +1V) because of the maximum display reading of -199,999 counts. This reduction in the dynamic range of the measurement is illustrated in Figure 2-4. In DCV function, both the Display Dynamic Range and the input dynamic range can be exceeded and thus, both can limit the dynamic range of the measurement. In ACV and Ω , only the input dynamic range can be exceeded.

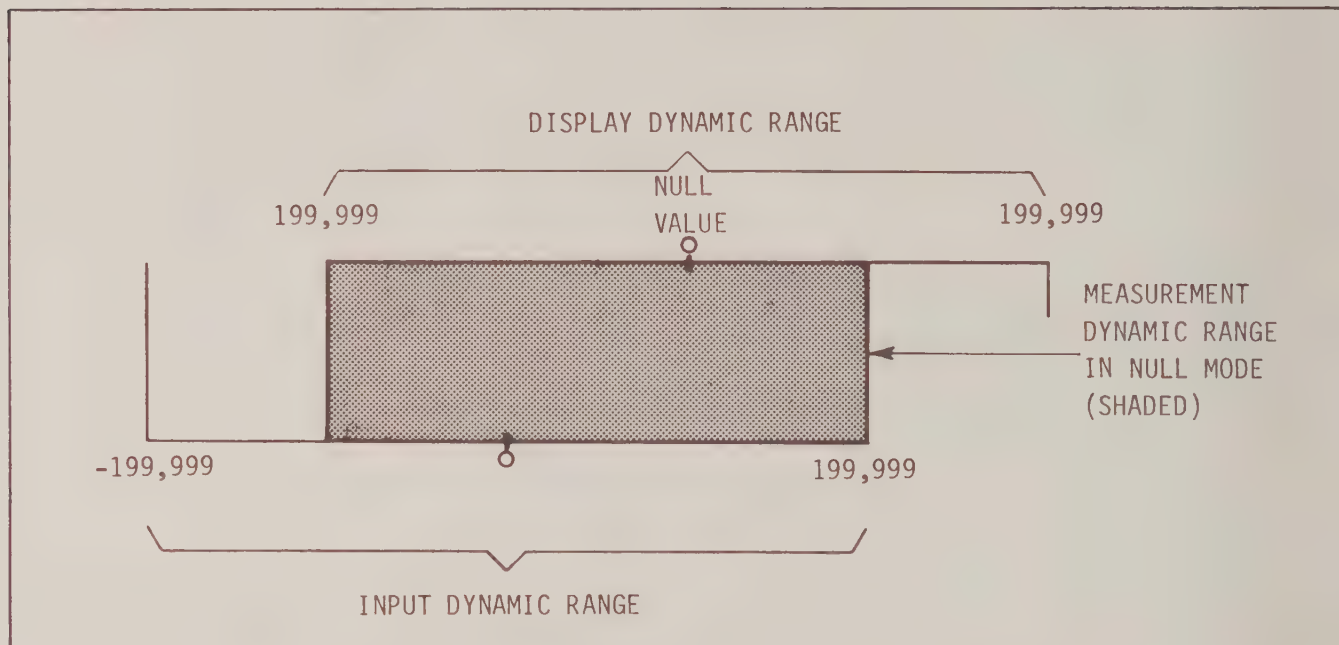


FIGURE 2-4. Effect of NULL function on Dynamic Range of Measurement.

2-18. The Use of NULL as pushbutton "zero" is described in DC Voltage and Ω Measurement Procedures.

2-19. OVERRANGE INDICATION.

2-20. Overrange is indicated by the minus sign along with the overrange digit and the appropriate decimal point. All of the remaining less significant digits are blanked. Example: (-1--.--). Overrange is indicated whenever the dynamic range of the measurement is exceeded. With the NULL function off, this occurs above $\pm 199,999$ counts. As described in Paragraph 2-17, the dynamic range of the measurement is reduced by an amount determined by the size and polarity of the nulled signal when the instrument is in the null mode.

2-21. ERROR INDICATION.

2-22. -IEEEEE is displayed when an improper range - function is selected. These selections are:

ACV function - when AC option is not installed.

20M Ω range - with ACV or DCV function selected.

ACV function - with 200 Ω , 200mV range selected.

2-23. DC VOLTAGE MEASUREMENT.

2-24. The Model 191 reads dc voltages from 1 microvolt/digit to 1200 volts. The maximum displayed reading is 199999. Overrange is indicated by (-)1-----, except on 1200 volt range. On the 1200 volt range, the display can read beyond the maximum allowable input voltage. Maximum allowable input: 1200V for 1 minute maximum, 700 volts continuous on the 200mV and 2V ranges; 1200 volts continuous on the 20V-1200 volt ranges. Use the Model 191 to measure dc voltage as follows:



CAUTION

Do not exceed the maximum allowable input voltage limits. Instrument damage may occur.

a. Turn on power with the ON/OFF pushbutton and depress the DCV pushbutton.

b. Select the desired range from the five ranges available. The decimal point is positioned by the range pushbutton. The 1200 VDC range is selected by the 1000 pushbutton.

c. Ensure that the NULL pushbutton is out (light off) unless measurements are to be made as deviations from a preset value.

d. Connect the signal to be measured between the INPUT HI and LO binding posts. The binding posts accept wires, spade lugs or banana plugs for ease of connecting the circuit to be measured. Low thermal cabling and connections are recommended for measurements on the 200mV range.

e. For the top four ranges, merely observe the displayed digits, polarity sign and decimal point locations. The top four ranges are direct-reading in volts.

f. For the 200mV range, ZERO must set with the NULL function to obtain rated accuracy. Zeroing is necessary to compensate for thermal EMF's generated by the connections to the circuit to be measured. These voltages may be only a few microvolts or several tens of microvolts. Set zero as follows:

- 1) Set Model 191 to 200mV range.
- 2) Disconnect the test leads at the circuit to be measured and short them.
- 3) Depress the NULL pushbutton.
- 4) Reconnect the test lead and make the measurement by applying the signal and reading millivolts on the display.

g. The optional Model 1600 High voltage Probe can be used with the Model 191 to measure dc voltages up to 40 Kilovolts, at reduced accuracy. Refer to Paragraph 2-30.

2-25. RESISTANCE (Ω) MEASUREMENT.

2-26. The Model 191 DMM measures resistance from 1 milliohm/digit to 20 megohms. See Table 2-3 for ranges. The Model 191 provides automatic 2-wire or 4-wire ohms operation. This means that if the ohms sense leads are connected, the measurement is automatically done 4-terminal. If the sense leads are not connected, the measurement is done 2-terminal. For 4-terminal measurements rated accuracy (+1 digit) can be obtained on all ranges as long as the maximum lead resistances given in Table 2-3 are not exceeded. For 2-terminal measurements on the 200 Ω range, zero must be set by the NULL function to obtain rated accuracy. Use the Model 191 to measure resistance as follows:



CAUTION

MAXIMUM ALLOWABLE INPUT VOLTAGE (all ranges): 360V peak, 250V rms. Do not exceed maximum voltage. Instrument damage may occur.

- a. Turn on power and depress Ω pushbutton.
- b. Connect the circuit to be measured to the INPUT terminals and select the desired range from the six ranges available. The decimal point is positioned by the range pushbutton.

TABLE 2-3
Resistance Ranges

RANGE SETTING	MAXIMUM READING	MAXIMUM OUTPUTS* I(Shorted) V(Open)		4-WIRE Max. Ω **
200 Ω ***	199.999	-4mA	-400mV	7 Ω
2k Ω	1.99999	-4mA	-4V	22 Ω
20k Ω	19.9999	-400 μ A	-4V	70 Ω
200k Ω	199.999	-40 μ A	-4V	220 Ω
2000k Ω	1999.99	-4 μ A	-4V	700 Ω
20M Ω	19.9999	-.4 μ A	-4V	2200 Ω
ALL RANGES				
		OVERRANGE: -1-----		MAXIMUM ALLOWABLE INPUT: 360Vpeak, 250Vrms

* HI binding post (red) is negative.

** Maximum resistance per lead for additional 1 digit error.

*** Zero must be set by NULL to obtain rated accuracy.

c. For 4-terminal measurement connect the sense leads to the circuit to be measured and to the Ω SENSE terminals on the 191. This arrangement eliminates the error due to the voltage drop across the current-carrying leads.

d. Ensure that the NULL pushbutton is out (light off) unless measurements are to be made as deviations from a preset value.

e. For all ranges of 4-wire ohm measurements and the top five ranges of 2-wire measurements, merely observe the displayed digits and decimal point to make the measurement.

f. For a 2-wire ohms measurement on the 200 Ω range, ZERO must be set with the NULL function to obtain rated accuracy. Zeroing is necessary to compensate for test lead resistance. Set zero as follows:

- 1) Disconnect the test leads at the circuit to be measured, and short them.
- 2) Depress NULL pushbutton.
- 3) Reconnect the test leads and make the measurement.

g. Diode Test. The 2K Ω range is recommended for diode testing. On this range the forward on resistance of a silicon diode will read approximately 190 Ω .

2-27. AC VOLTAGE MEASUREMENT (WITH 1910 AC OPTION).

2-28. With the Model 1910 option, the Model 191 reads ac voltages from 10 microvolts/digit to 1000 volts. The instrument reads the root mean square value of a sine wave with a frequency of 50Hz to 100kHz. Accuracy is specified for 1000 counts and above. The maximum reading is 199999. Overrange is indicated by (-) 1-----, except on 1000 volt range. On the 1000 volt range, the display can read beyond the maximum allowable input voltage. Maximum allowable input: 1000V rms or dc; $2 \times 10^7 \text{V} \cdot \text{Hz}$. Use the Model 191 to measure ac voltage as follows:



CAUTION

Do not exceed maximum allowable input voltage. Instrument damage may occur.

- a. Turn on power with ON/OFF pushbutton and depress the ACV pushbutton.
- b. Select the desired range from the 4 ranges available. The decimal point is positioned by the range pushbutton.
- c. Ensure that the NULL pushbutton is out (light off) unless measurements are to be made as deviations from a preset value.

d. Connect the signal to be measured between the INPUT HI and LO binding posts. The binding posts accept wires, spade lugs or banana plugs for ease of connecting the circuit to be measured. Observe the displayed digits and decimal point.

e. The Model 1682 RF Probe can be used with the Model 191 to measure 0.25V to 30V rms ac signals with a frequency 100kHz to 100MHz (and above at reduced accuracy). Refer to Paragraph 2-36.

2-29. ACCESSORIES

2-30. MODEL 1600 HIGH VOLTAGE PROBE.

2-31. The Model 1600 extends the DMM to 40kV. It has a 1000:1 division ratio which means that 1 volt on the DMM corresponds to 1 kilovolt.

To Operate: Set the DMM to DCV and 200 Volt range. Connect the banana plug on the Model 1600 to the INPUT terminals. Connect the alligator clip on the Model 1600 to source low. Connect the probe tip to source high.

Specifications: Voltage Range: 0 to 40,000 volts DC.

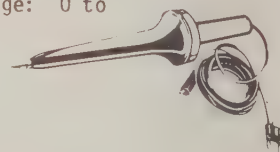
Input Resistance:
1000 megohms.

Division Ratio: 1000:1.

Ratio Accuracy
±1.5% at 25kV, decreasing to
±2.0% at 20kV and 30kV
±3.0% at 10kV and 40kV, and
±4.0% at 1kV.

Ratio Stability: ±0.01% per °C; ±0.1% per year.

Heating Effects: Self-heating due to application of high voltage for period in excess of 1 minute will cause a maximum of 0.2% additional error at 40kV (error is less at lower voltage).



2-32. MODEL 1651 50-Ampere Shunt

2-33. The Model 1651 allows current measurements to be made from 0 to 50 amperes DC and from 10 to 50 amperes AC with AC Voltage option. It is a 0.001ohm ±1% 4 terminal shunt. A fifty ampere current will correspond to 50 millivolts.

To operate: Connect separate current leads (not furnished) between the source and the Model 1651 hex-head bolts. Use leads that are rated up to 50 ampere capacity. Connect the voltage leads (furnished) between the Model 1651 screw terminals and the DMM INPUT terminals. Set the DMM to ACV and 2V range or DCV and 200 millivolt range.



2-34. MODEL 1681 CLIP-ON TEST LEAD SET.

2-35. The Model 1681 contains two leads 1.2m (48 inches) long, terminated with banana plug and spring-action clip-on probe.

**2-36. MODEL 1682 RF PROBE.**

2-37. The Model 1682 extends the AC voltage response of the Model 191 from 100kHz to 100MHz.



To Operate: Set the DMM to DCV and 200 Volt range. Connect the Model 1682 to the DMM INPUT terminals.

Specifications:

Voltage Range: 0.25 to 30 volts rms.

Transfer Accuracy: $\pm 0.5\text{dB}$, 100kHz to 100MHz peak responding calibrated in rms of a sinewave.

Input Impedance: 4 megohm shunted by 3pF.

Maximum Allowable Input: 30V rms AC, 200V DC.

Accessories Supplied: straight tip, hook tip, ground clip, hi adapter, banana plug adapter.

2-38. MODEL 1683 UNIVERSAL TEST LEAD KIT.

2-39. Two test leads, 1.2m (48 inches) long with 12 screw-in tips - 2 banana plugs, 2 spade lugs, 2 alligator clips with boots, 2 needle tips with chucks and 4 heavy duty tip plugs.

2-40. Model 1684 Carrying Case

2-41. The Model 1684 is a hard vinyl case with a fitted foam insert with room for the Service Manual and small accessories.

**2-42. MODEL 1685 CLAMP-ON AC CURRENT PROBE.**

2-43. The Model 1685 measures AC current by clamping onto a single conductor. Interruption of the current path is unnecessary. The Model 1685 detects current by sensing magnetic field produced by current.

To Operate: Set the DMM to ACV and 20 volt range. Connect the Model 1685 to the DMM INPUT terminals. The DMM will display 0.1 volts per ampere.

Specifications:

Range: 2, 20 and 200 amperes rms.

Accuracy: $\pm 4\%$ of range at 60Hz. $\pm 6\%$ of range at 50Hz.



Temperature Coefficient: $\pm 0.05\%/^{\circ}\text{C}$ on the 20 and 200 ampere range. $\pm 0.3\%/^{\circ}\text{C}$ on the 2 ampere range.

Maximum Allowable Current: 300 amperes rms.

Maximum Conductor Voltage: 600 volts rms.

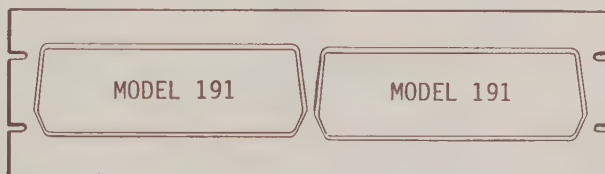
Conversion Ratio: 0.1 volt rms per ampere.

2-44. MODEL 1010 SINGLE RACK MOUNTING KIT.

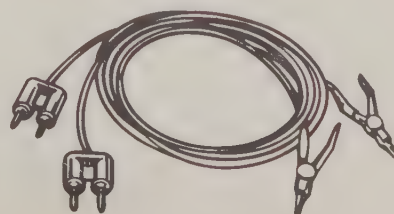
2-45. The Model 1010 is a single rack mounting kit with overall dimensions 5-1/4 inches (133mm) high and 19 inches (483mm) wide.

**2-46. MODEL 1017 DUAL RACK MOUNTING KIT.**

2-47. The Model 1017 is a single/dual mounting kit with overall dimensions 5-1/4 inches (133mm) high and 19 inches (483mm) wide.

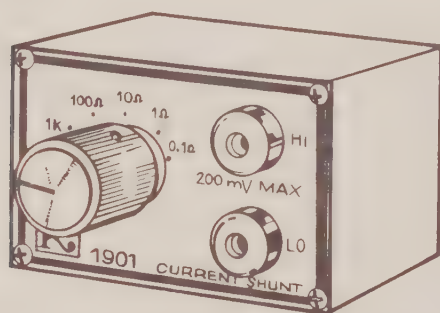
**2-48. Model 1641 Kelvin Test Lead Set.**

2-49. The Model 1641 test leads are for use in making 4-terminal measurements. The test leads (1 pair) are 1.2m (48 inches) long twin-lead cables. Each cable is terminated by a twin-banana plug and a spring-clip Kelvin contact. Plug twin banana plug into DMM horizontally (HI to HI and LO to LO).



2-50. Model 1901 Current Adapter.

2-51. The Model 1901 allows your DMM to read dc current from 1nA/digit to 2000mA. With the 1910 AC Voltage Option it reads from 10nA/digit to 2000mA. The Model 1901 plugs into the INPUT terminals of the 191. Maximum allowable continuous voltage drop (full scale input voltage burden) is 200mV. Shunt resistors are connected so as to eliminate contact resistance errors. Use the Model 191 200mV dc range and 2V ac range, for dc current and ac current respectively. Input voltage burden can be reduced by selecting the lowest shunt that provides the necessary resolution.

**2-52. Model 1910 AC Voltage Option.**

2-53. The Model 1910 (not shown) is a factory or field installable option which allows your DMM to read ac volts from 10μV/digit to 1000V. The Model 1910 is internally installed in the Model 191. It is important to note that field installation or removal/replacement of the Model 1910 requires recalibration of ac voltage. Specifications for the 1910 are given in Table 1-1 and ac voltage measurements are described in Paragraph 2-27.

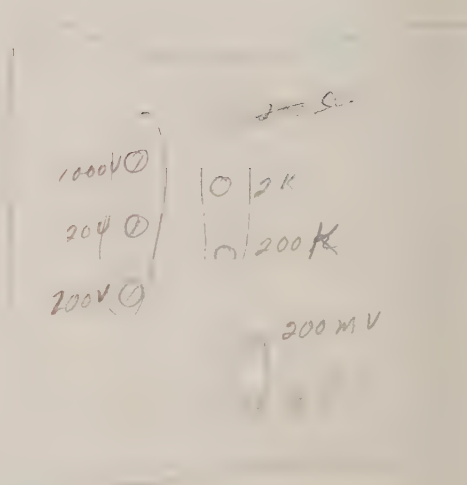
2-54. Model 1913 Calibration Cover Kit.

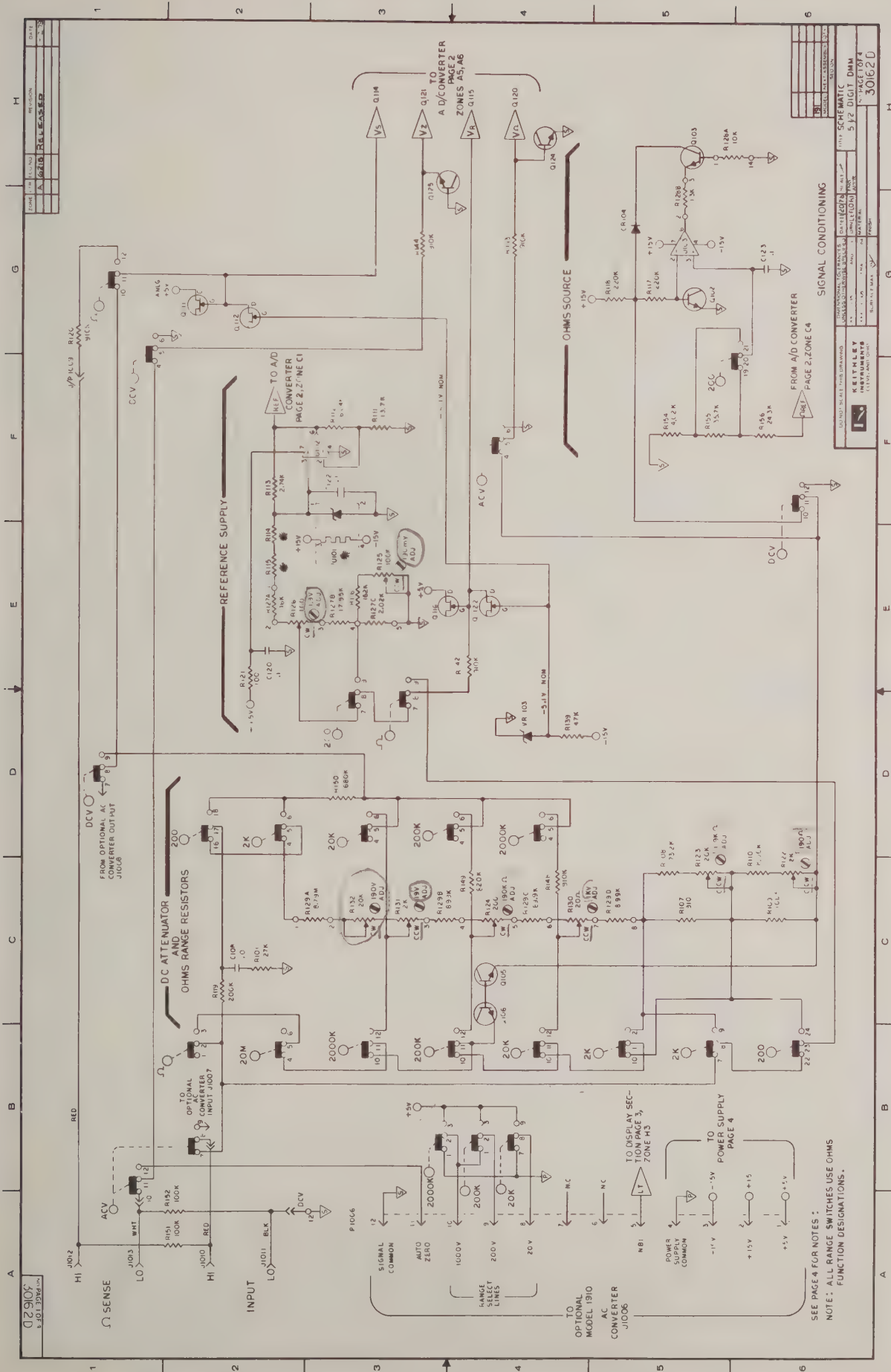
2-55. The 1913 (not shown) contains a calibration cover and an Instruction/Service Manual for the Model 191 DMM. The calibration cover is installed in place of the normal 191 top cover during calibration. It allows the 191 to reach normal internal operating temperature and has openings that are marked to facilitate making the calibration adjustment.

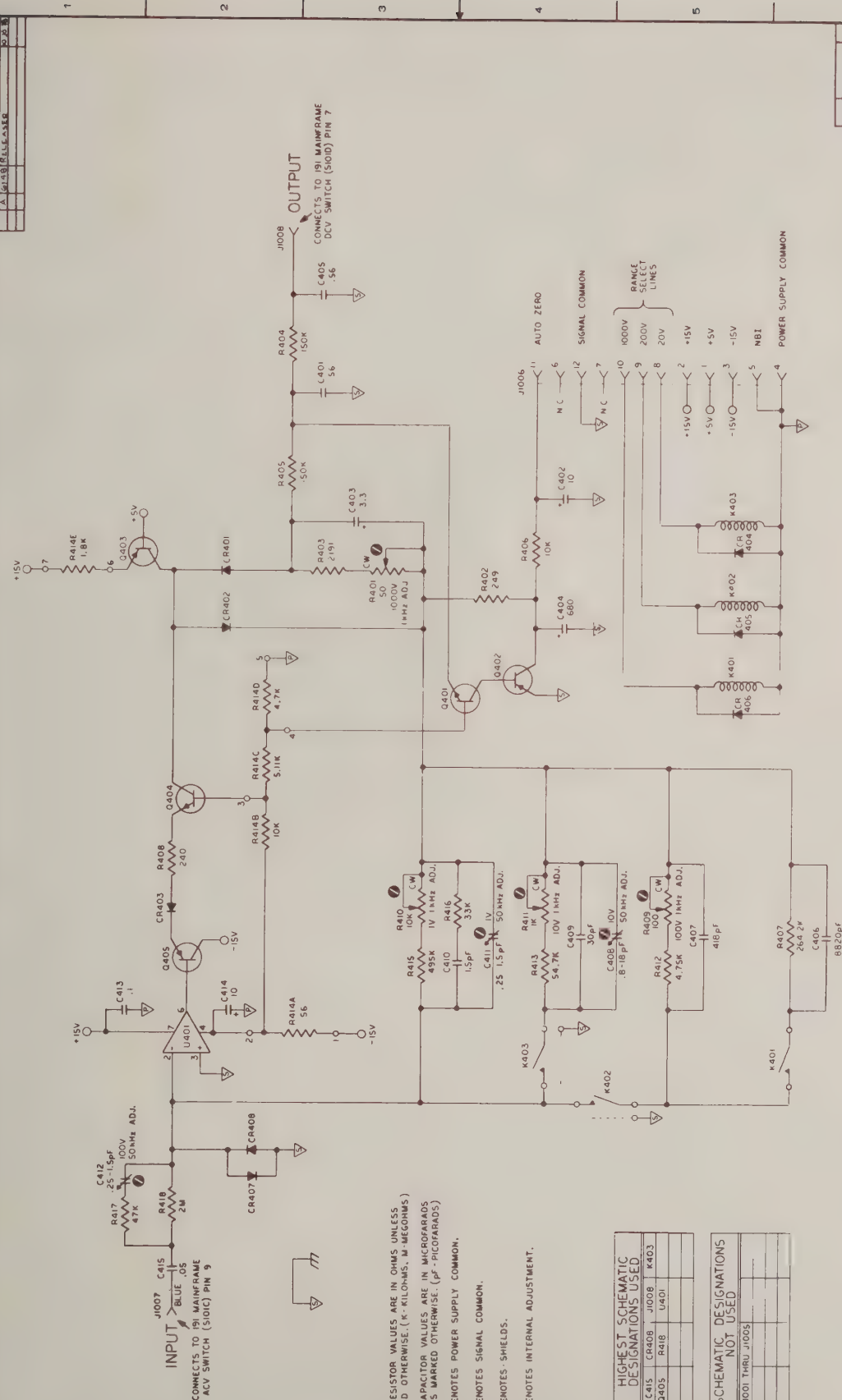
2-56. REFERENCE DRAWINGS.

2-57. The schematics listed below are provided following this page.

- a. Number 30162D Model 191 5-1/2 Digit DMM Sheet 1 through 4.
- b. Number 29960D Model 1910 AC Option.







NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE. (K=KILOHMS, M=MEG OHMS)
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE. (P=PICOFARADS)
3. ∇ DENOTES POWER SUPPLY COMMON.
4. ∇ DENOTES SIGNAL COMMON.
5. ∇ DENOTES SHIELDS.
6. ∇ DENOTES INTERNAL ADJUSTMENT.

HIGHEST SCHEMATIC DESIGNATIONS USED			
C415	CR408	J1008	K403
Q405	R418	U401	

SCHEMATIC DESIGNATIONS NOT USED	
J1001 THRU J1005	

SERVICE FORM

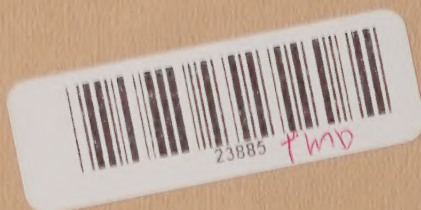
R-

NAME _____ PHONE _____

COMPANY _____

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8. Additional Information. (If special modifications have been made by the user, please describe below.)



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